United States Patent [19]

Compton

[11] **3,786,248**

[45] **Jan. 15, 1974**

[54] **LUMINAIRE**

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[73] Assignee: **Kim Lighting, Inc.,** City of Industry, Calif.

[22] Filed: **May 15, 1972**

[21] Appl. No.: **253,591**

[52] **U.S. Cl.** .... **240/25,** 240/41.37, 240/73 BC, 240/103

[51] **Int. Cl.** **F21s 1/10,** F21s 3/10, F21s 13/10

[58] **Field of Search**.................... 240/25, 41.37, 73, 240/103

[56] **References Cited**

UNITED STATES PATENTS

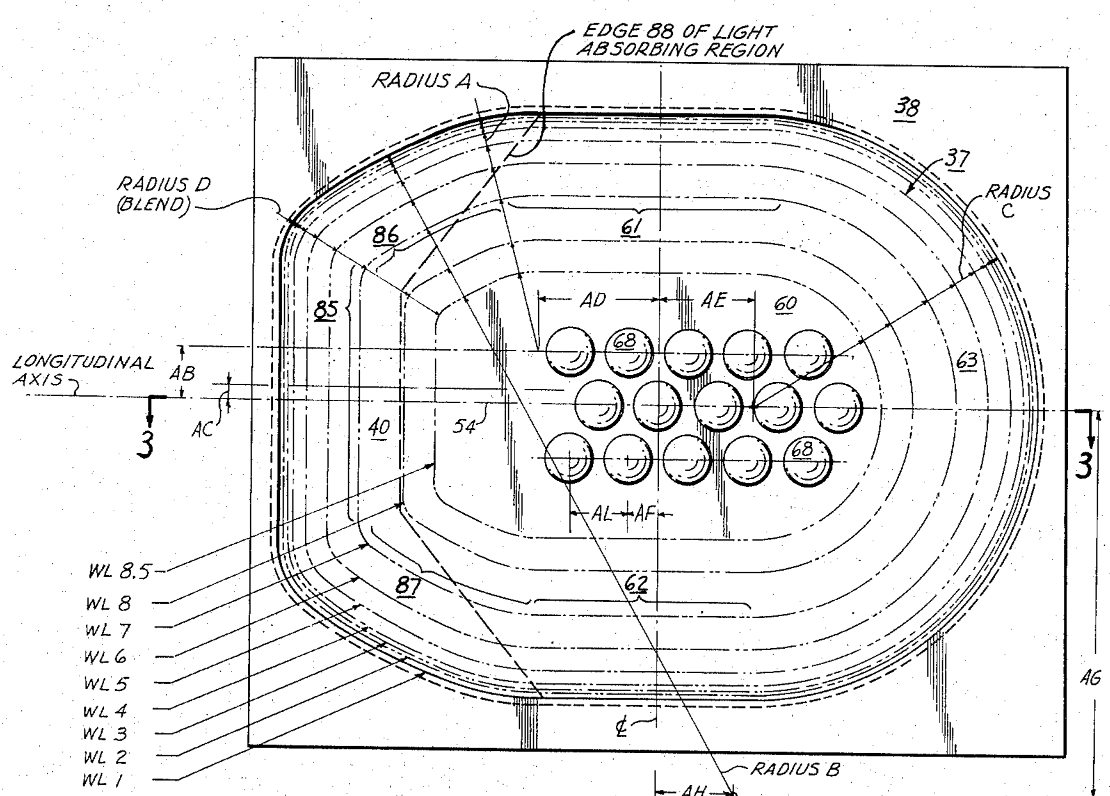
3,179,793	4/1965	Franck	240/25
3,189,739	6/1965	McPhail	240/25
3,350,556	10/1967	Franck et al.	240/25

Primary Examiner—Samuel S. Matthews
Assistant Examiner—Richard A. Wintercorn
Attorney—D. Gordon Angus et al.

[57] **ABSTRACT**

A luminaire comprising a lamp and a reflector. The lamp has an axis of radiation and the property of emitting a disproportionately large percentage of its luminous flux in an annulus which is contained within a pair of imaginary divergent conical surfaces, each at no more than about 50° to the axis of radiation (100° included angle). The reflector includes reflective cap, side and end surfaces which together form a cavity in which the lamp is placed. The cavity has a plane of symmetry. A longitudinal axis and the axis of radiation lie in the plane of symmetry. The axis of radiation intersects the longitudinal axis at an acute angle. The side and end surfaces are, in cross-section, beaming-directing, and preferably are at least approximations to parabolas, and the flux radiated from the lamp within said annulus impinges upon each of these surfaces.

32 Claims, 12 Drawing Figures



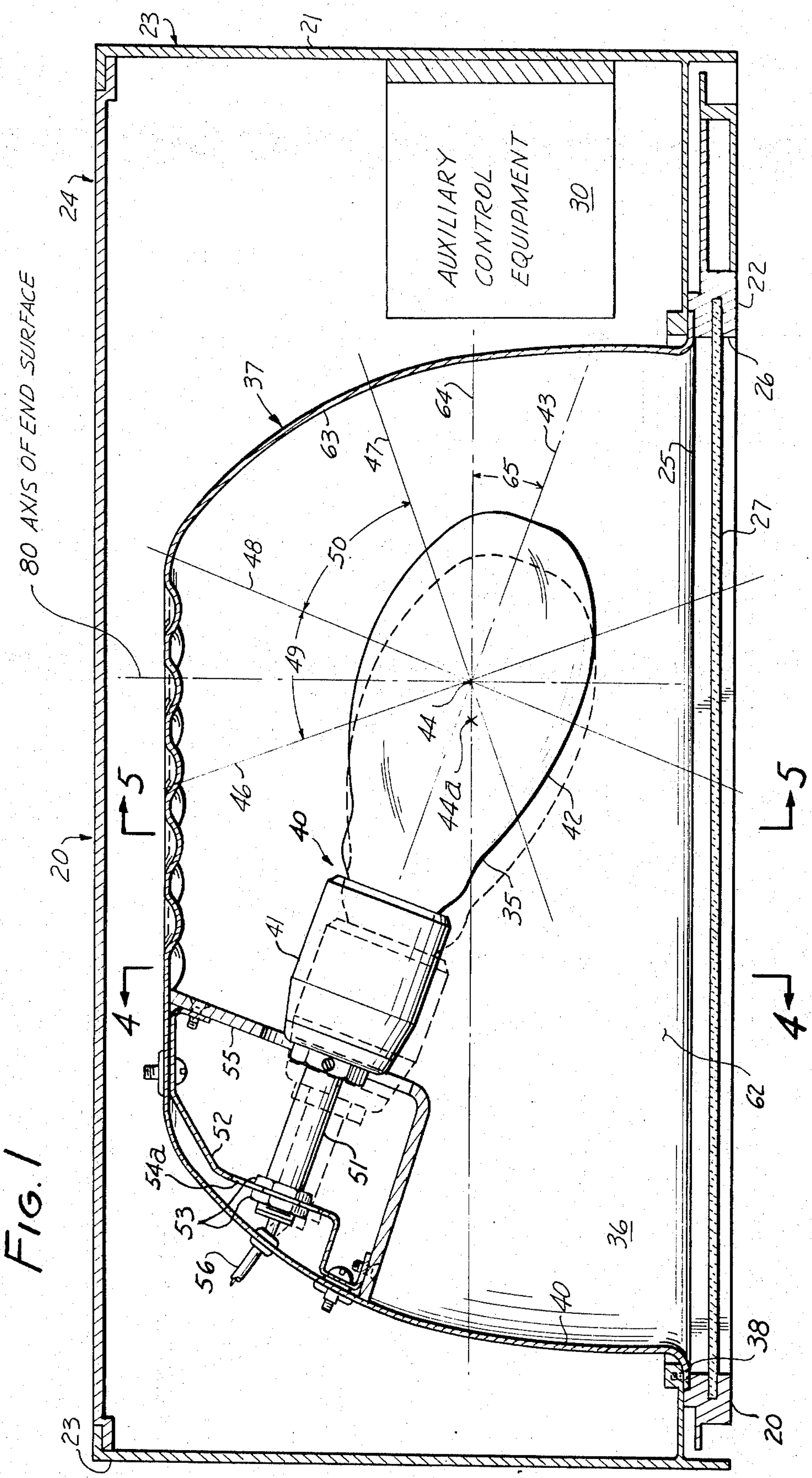


FIG. 1

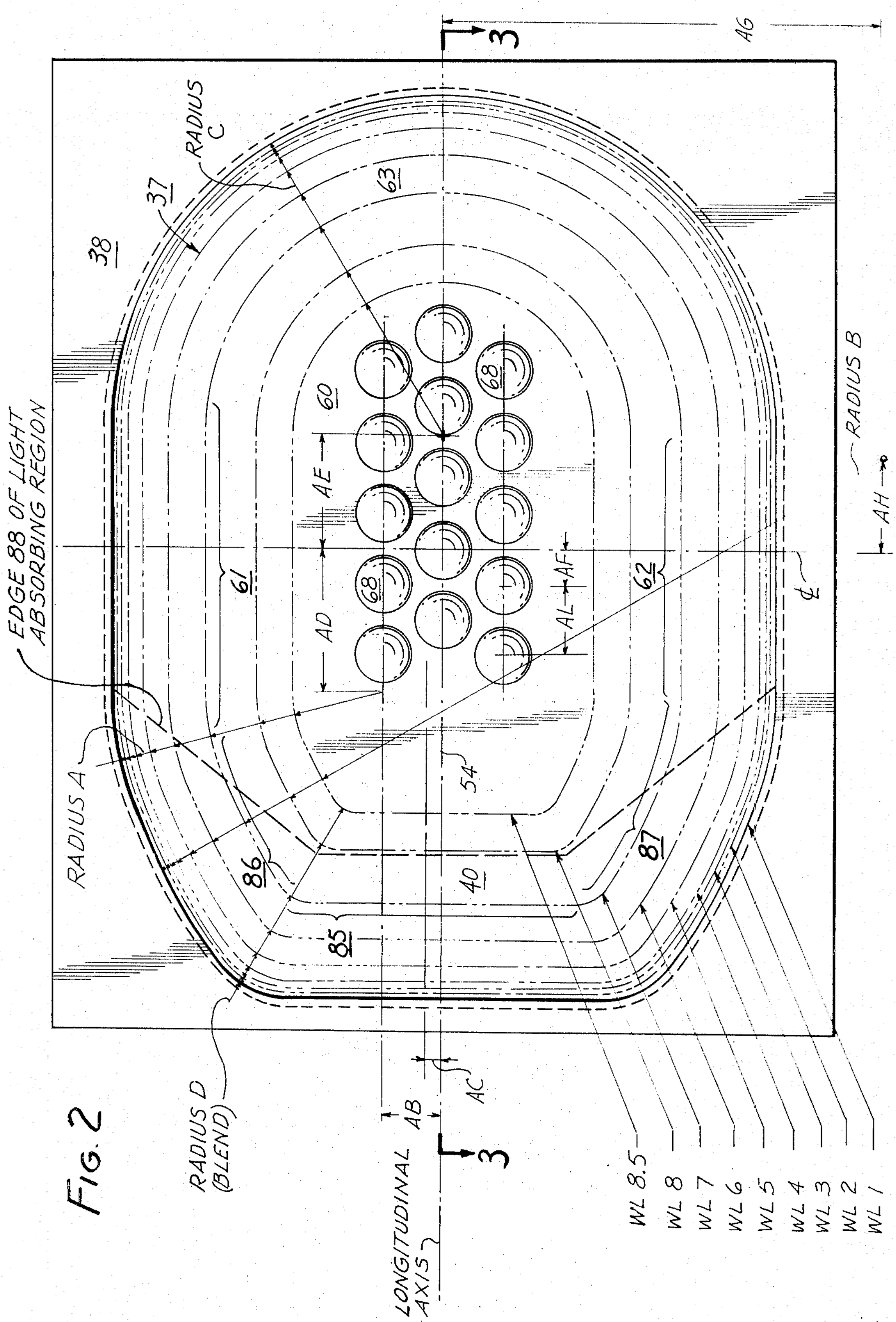

3
AG
RADIUS C
37
38
63
60
68
AE
AD
61
62
AF
AL
AH
RADIUS B
EDGE 88 OF LIGHT ABSORBING REGION
RADIUS A
54
86
87
40
85
RADIUS D (BLEND)
AB
AC
LONGITUDINAL AXIS
WL 8.5
WL 8
WL 7
WL 6
WL 5
WL 4
WL 3
WL 2
WL 1

FIG. 2

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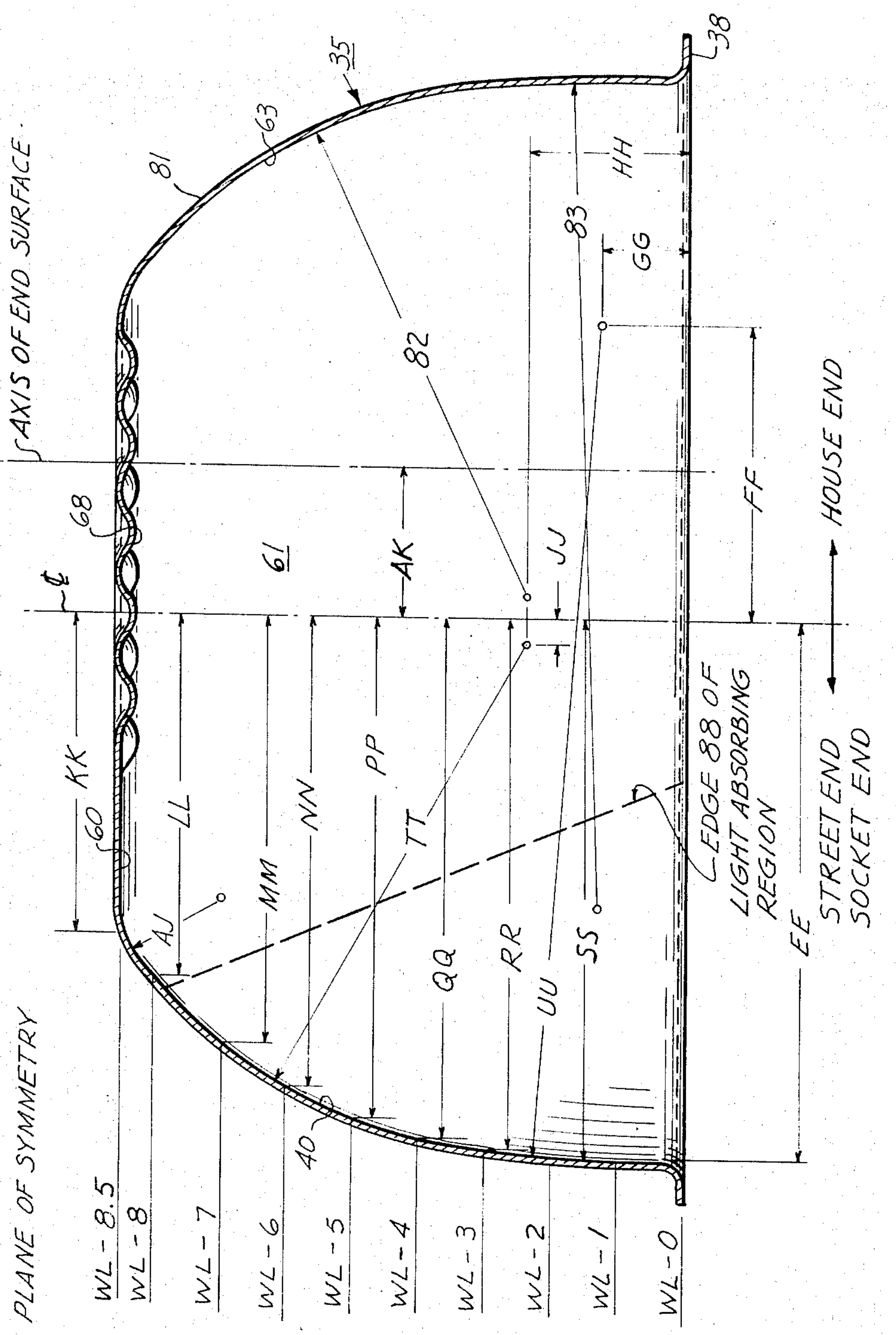
FIG. 3



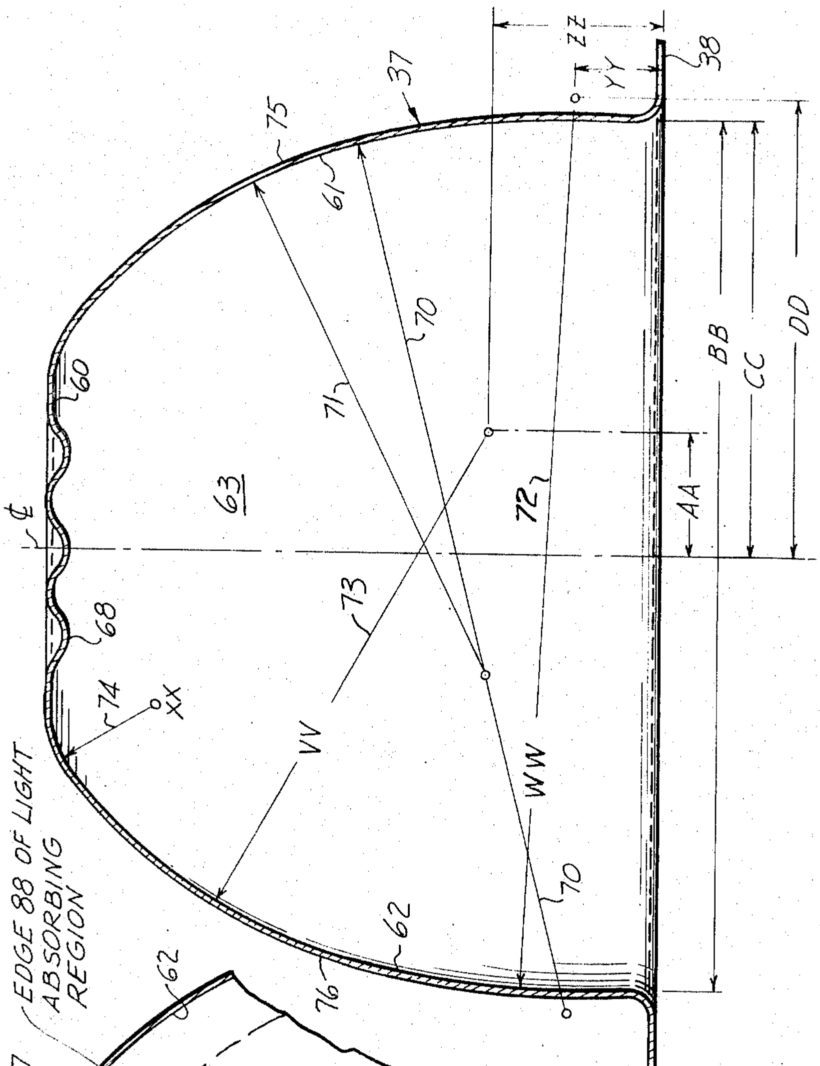

ZZ
YY
38
37
75
61
70
71
60
63
72
AA
BB
CC
DD
68
73
74
XX
VV
WW
70
62
76

FIG. 5

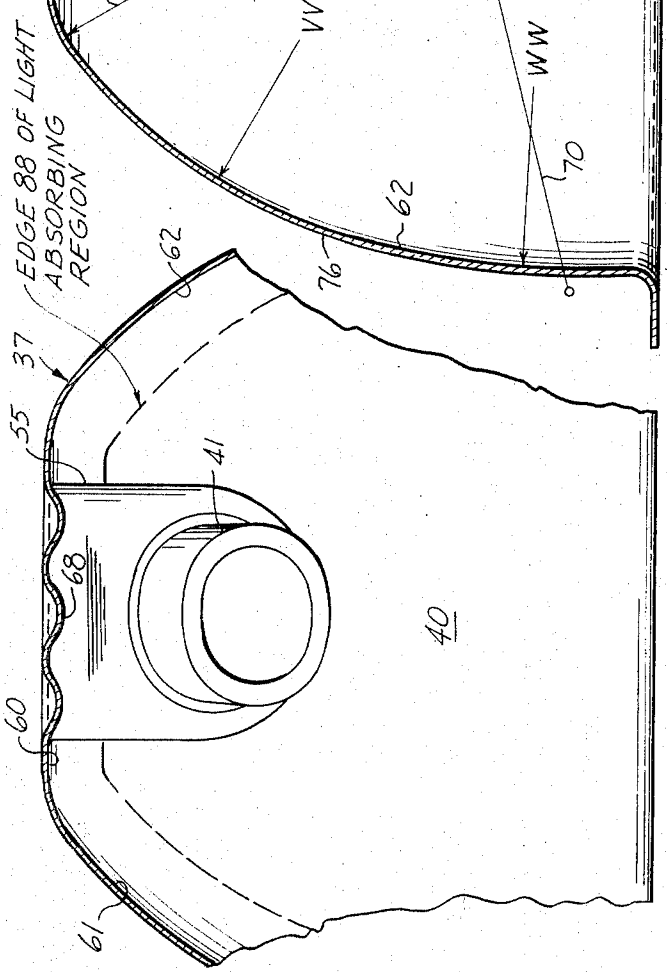

EDGE 88 OF LIGHT ABSORBING REGION
62
37
55
41
68
40
60
61

FIG. 4

FIG. 6

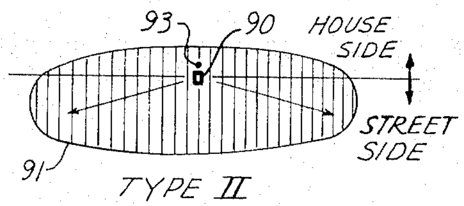


FIG. 7

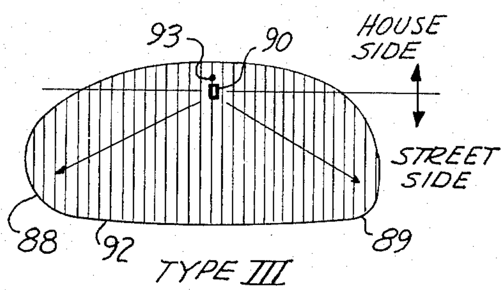


FIG. 8

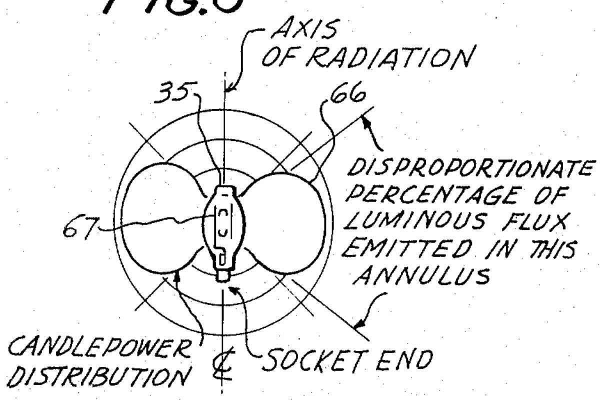


FIG. 9

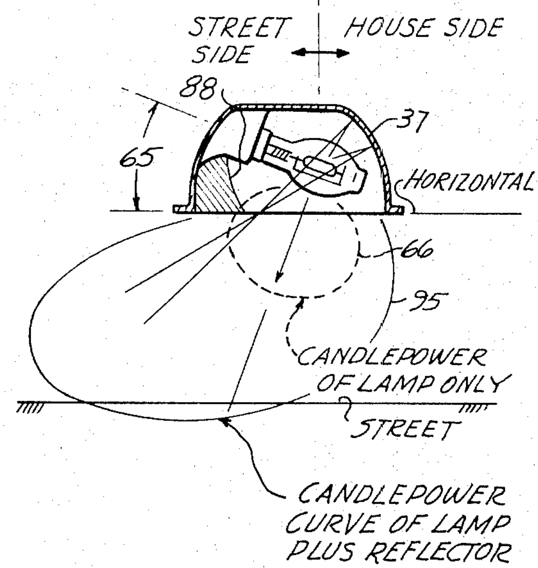


FIG. 10

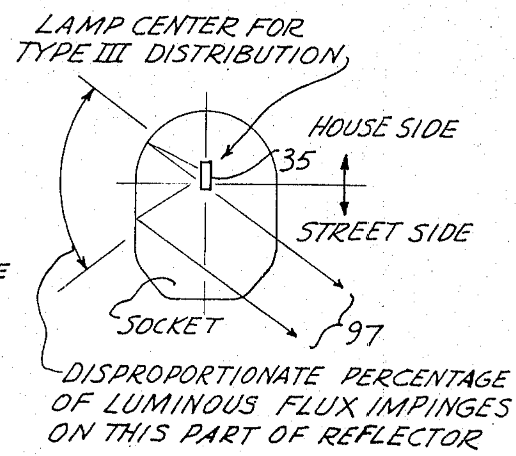


FIG. 11

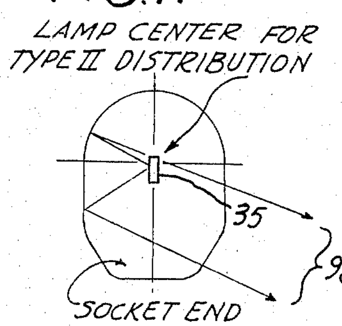
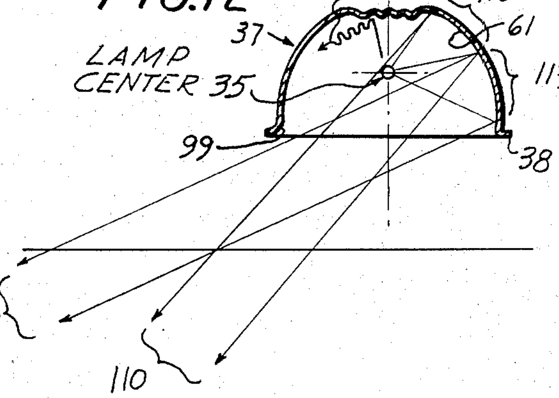


FIG. 12



LUMINAIRE

This application relates to luminaires, and in particular to the combination of a lamp and a reflector which have interrelated physical properties.

As requirements for illumination of large areas have multiplied, so too have the consequences of the shortcomings of existing devices for this purpose, which depend heavily upon refracting bodies for their control of the light. One objection which is heard with increasing frequency concerns visual pollution of the environment caused by glare light scattered by conventional luminaires. Not only is the background glow brightened by this glare, but the stray light in itself is unpleasant and even potentially harmful, such as by causing windshield glare. Also, it reduces the contrast between an illuminated object, such as a person walking along a sidewalk, and the background. This endangers the person, because he is, in effect, less visible. Such contrast should be made as pronounced as possible. As still another objection, the stray light causes pupillary constriction. Such constriction limits the ability of the human vision system to identify illuminated objects.

The increased power consumption needed in order to provide a specific light intensity at the surfaces to be illuminated, when light is wasted by glare, raises energy bills.

Yet another disadvantage of the prior art resides in the tendency of existing illumination means to form "hot spots", or areas of excessive lighting, while leaving other areas poorly lighted, all within the intended distribution region of the luminaire.

It is an object of this invention to provide a luminaire which can illuminate substantial areas with much closer approximation to uniformity of illumination than has been possible with prior art reflectors or refractors.

It is another object of this invention to provide a luminaire which has relatively sharp cut-offs of illumination, thereby concentrating its light in a restricted, intended area.

Still another object of this invention is to accomplish the foregoing objectives with the use of commercial lamps which are readily available on the market, and which can be enclosed in relatively small enclosures so the luminaire constitutes only a minimum visual disruption to the surroundings.

Yet another object of the invention is to provide a luminaire whose distribution of light can be asymmetrical—illuminating regions farther to one side of the luminaire than to the other—while utilizing a reflector whose bottom edge is horizontal. With the reflector of this invention, asymmetric distribution does not require tilting the reflector, or the use of a refractor, and therefore the observer does not see a bright light source as he views the luminaire from the side or front. This is one of the major advantages of this invention. With it, one can illuminate an area farther removed from the luminaire on one side than on the other, and still the emitting region is not tilted so as to be visible as a bright area in the sky.

This invention provides an elegantly simple luminaire which in itself is inoffensive in appearance, which illuminates areas with considerable consistency without appreciable stray glare, and which is readily adjusted to provide for different configurations of illumination of areas beneath it.

A luminaire according to this invention comprises in combination a lamp which emits visible light, and a reflector. The lamp is of the type which has an axis of radiation and the property of emitting a disproportionately large percentage of its luminous flux in an annulus bounded by a pair of imaginary surfaces of revolution generated around the axis of radiation by generator lines which, in an axial plane, diverge from the normal to the axis of radiation by no more than about 50°. The reflector has a longitudinal axis and a plane of symmetry which includes both the longitudinal axis and the axis of radiation. The reflector forms an open, inwardly concave cavity in which the lamp is placed. The cavity is bounded, at least in part, by the following reflecting surfaces: a) a cap surface which overlays the cavity and extends generally along and transverse to the said longitudinal axis; b) a pair of concave side surfaces, one on each side of the plane of symmetry, each intersecting the cap surface and extending generally along said longitudinal axis; and c) a concave end surface which intersects and interconnects both side surfaces and the cap surface. These surfaces are specularly reflective over the major portion of their areas. The axis of radiation forms an acute angle with the longitudinal axis. The flux within the annulus impinges upon each of the said surfaces.

According to a preferred but optional feature of the invention, some portions of the cap surface are modified by light-diffusing facets.

According to still another preferred but optional feature of the invention, the section lines of the side and end surfaces are beam controlling, and in gross are at least approximations to parabolas.

According to still another preferred but optional feature of the invention, the said section lines comprise the arcs of at least two circles of different radius.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawings in which:

FIG. 1 is a side view, principally in axial cross-section of the presently preferred embodiment of the invention taken along its plane of symmetry;

FIG. 2 is a bottom view of FIG. 1, looking upwardly into the cavity;

FIG. 3 is a cross-section taken at line 3—3 of FIG. 2;

FIG. 4 is a fragmentary cross-section taken at line 4—4 of FIG. 1;

FIG. 5 is a cross-section taken at line 5—5 of FIG. 1; and

FIGS. 6–12, inclusive, are sketches that are explanatory of certain features of the invention.

A luminaire 20 according to the invention is shown in FIG. 1. It is fitted into a housing 21 which, because of the compactness of the elements it contains, may be made as a rectangular parallelopiped. This housing may readily be attached to a pole or some other kind of support, such as a wall.

It is desirable, and in general will be the situation, that the lower surface 22 of the housing will be parallel to the ground. It is a particular advantage of this invention that such an arrangement can be made. Conventional luminaires accomplish asymmetrical distribution of light by tilting the luminare and/or reflector, or by using refractors. In so doing, their refractors or reflectors, or both, are directly exposed to and visible by the observer, and become a prime source of nighttime visual pollution. Such refractors, reflectors, or both are a common sight on the night-time skyline. The term "asymmetrical distribution" means that more light is directed to one side of a plane normal to the longitudinal axis than to the other side of the axis.

The housing includes four sides **23**, a top **24**, and an open base **25**. The base has an aperture **26** in which a transparent pane **27** is fitted. The pane is readily removable from its supporting frame **28**. The frame is attached to the housing.

Auxiliary control equipment **30** is fitted inside the housing. Such equipment may include ballast, capacitors, circuit boards, switches and leads. Connections are made to the auxiliary control equipment and from this equipment to the lamp socket. The foregoing are all conventional elements and require no detailed description here, because they form no part of the invention.

A lamp **35** is supported inside a cavity **36** formed by a reflector **37**. The reflector is supported at its edge **38** by the housing. It fills aperture **26**, and flux from the lamp is emitted through the aperture. The lamp and reflector will now be described in further detail.

Lamp **35** is of a conventional type used in the illumination field. The illustrated lamp is a **175** or **250** watt mercury vapor lamp. As other examples, there may instead be used high pressure sodium lamps or metallic halide lamps. All of these lamps have a socket end **40** which is to be screwed into a socket **41**, and a glass envelope **42**. They also have an axis of radiation **43** which is linear. A feature of the class of lamp useful in this invention is that, with respect to the axis of radiation and a theoretical center **44** thereon, there is an annulus generated around the lamp axis which contains a disproportionately large percentage of the luminous flux emitted by the lamp compared to the percentage of the flux emitted outside this annulus. For example, such an annulus is imaginary generated by a pair of generator lines **46, 47** which diverge from from the normal **48** (a normal plane) to the axis of radiation by angles **49, 50** which are about **50°**. In most lamps of the type described, about 75 percent of the luminous flux is emitted in such an annulus in which the total of angles **49** and **50** is less than about 100°. This means that relatively little light is emitted rearwardly toward the socket end, or forwardly toward the tip end of the lamp. The candlepower distribution of this type of lamp is shown in FIG. **8**. The distance of the solid line **66** from the center **67** of the lamp graphically illustrates the intensity of lumination at the respective angular position around the center, the distance of line **66** from the center indicating the relative intensity at the respective angle. A greater distance from the center in this graph indicates a greater intensity.

The term "axis of radiation" defines an axis which is related to the pattern of light intensity emitted by the lamp. It is a central axis around which the aforesaid annulus is generated. In a conventional lamp wherein an arc tube is the light source, the intersections of generator lines **46** and **47** with the axis are spaced apart by an appreciable distance, perhaps an inch or more, and the annulus will not have a point center on the axis, but rather a line coincident with the axis. If the lamp were a theoretical point source, then the two lines would intersect at the axis of radiation. In either case, the axis would be the same, because it is referred to the pattern of emission, and not to the shape or nature of the light source itself.

For convenience, the theoretical center **44** is referred to. In a practical arc tube lamp, the center **44** is located at the mid-point of the envelope.

In order to provide different illumination patterns on the pavement with a given reflector, means is provided for supporting the lamp at predetermined locations along both the axis of radiation and the longitudinal axis of the reflector. For example, socket **41** is attached to nipple **51** and held to a mounting bracket **52** by lock nuts **53**. The bracket has an elongated slot **54**a. The lock nuts can be loosened to enable the nipple to be axially shifted to move the lamp axially, and vertically shifted in the slot to move the lamp vertically. The lamp can thereby be moved to various positions in the reflector, and the lock nuts tightened to hold it in the selected location. Two exemplary positions for the lamp are shown in the drawings, which will provide two different patterns of illumination. This adjustment feature also enables lamps of different sizes to be received and placed in selected locations.

The solid line socket position will hold the lamp in the location shown by solid line, and retraction and downward movement of the nipple will move the socket to the dashed line position where the envelope will be held in the position as shown by the dashed line with its center at **44**a instead of at **44**. It will thereby be seen that the flux within the annulus can be made to impinge differently on the reflector, depending on the location of the lamp in the cavity. Other means for locating the lamp in different positions may readily be devised, such as by stacking up adapter plugs between the lamp and a stationary socket. The lamp is held so that its axis of radiation remains in the plane of symmetry **54** of reflector **37**. The plane of symmetry is the plane of FIGS. **1** and **3**. The plane of symmetry shown is also a central plane. As will later become clear, the plane of symmetry is, in every case, a central plane. However, in every case, the central plane will not necessarily be a plane of symmetry, because the side surfaces are not necessarily identical, although they are identical in the preferred embodiment. A given lamp is also preferably supported so that its center **44** remains at a predetermined elevation when the position of the lamp in the reflector is changed.

A shroud **55** covers the mounting bracket and much of the socket. It serves to protect leads **56** from the heat of the lamp, and constitutes an esthetically pleasing envelope.

With initial reference to FIG. **2**, the reflector includes a cap surface **60**, a first side surface **61**, a second side surface **62**, and an end surface **63**. The side surfaces and end surface all intersect and blend into the cap surface. As can be seen in FIGS. **1** and **2**, the cap surface overlays the cavity and extends transversely relative to the longitudinal axis **64** of the reflector. The longitudinal axis lies in the plane of symmetry and extends in a direction which will ordinarily be parallel to the ground surface or to whatever surface is being illuminated. It extends midway between the two side surfaces. It forms an acute angle **65** with axis of radiation **43**. Ordinarily, this angle will be on the order of about 20°. The cap, side and end surfaces define an inwardly concave cavity in which the lamp is placed. The cavity opens onto a base plane, which may be defined as the plane of pane **27**. The base plane is parallel to the longitudinal axis, and in usual usage of the reflector, it will be parallel to the ground. The reflector need not be tilted to give an asymmetrical distribution.

To secure the desired asymmetrical distribution, it is necessary to provide surfaces which will specifically reflect light to each part of the illuminated area, and in a pattern wherein the intensity is reasonably uniform over the total illuminated region. As with any luminaire system, there is no abrupt fall-off from bright light to total dark in the sense of blackness in immediate contiguity with illumination. However, in contrast with conventional luminaires, a sharp fall-off from an acceptable level of illumination to a level of illumination which is not appreciably bright does occur within a remarkably small space. In order to accomplish this objective, reflecting surfaces with beam-forming properties.

The configurations of the foregoing surfaces will now be described. First, it will be remarked again that the annulus of the lamp is shown as though it originated at a central point **44**, while in a practical lamp the generator lines **46** and **47** will be separated from each other by a substantial distance along the axis of radiation because of the extended length of the arc tube of the lamp. However, whether the lamp has a point source or a line source, the geometry is substantially as shown. A point source is used for convenience in disclosure.

The annulus shown relates to the position of the lamp illustrated in solid line. In the illustration, if the lamp were about 8 inches long from the end of the socket to the tip of the glass envelope, the intersections of generator lines **46** and **47** with lamp axis **43** would be about **2** inches apart, thereby making the annulus longer than shown, in which case light within the annulus would strike a larger area of the surfaces. The luminous flux within the annulus, whatever the axial length, will impinge upon each of the cap surface, the side surfaces, and end surface **63.** Those portions of these surfaces which intersect the annulus will therefore determine the distribution of the major proportion of the luminous flux of the lamp. Some of the flux will, of course, pass directly from the lamp through aperture **26** without reflection.

The cap surface overlays the lamp. It is advantageous, but not necessary, to incorporate a plurality of down-light diffusing facets **68** into this surface. These facets serve to scatter light rather than to focus it, and perform two useful functions. One such function is to reduce hot spots on the ground beneath the reflector. Hot-spots are local regions which are appreciably brighter than neighboring regions within the area being illuminated. The scattered light tends to even out the distribution. The other advantage in scattering some of the light from the cap surface is that the amount of energy reflected back into the arc tube is reduced. Energy reflected into the arc tube shortens lamp life.

The preferred shape of the facets is, as shown, the convex polar section of a sphere. However, concave polar sections, and other concave and convex shapes may be used instead, to the same advantage.

Facets **68** do not scatter the light beyond the field limited by the reflector, because of the cut-off effect of the outer edge of the aperture **26.** They do, however, appreciably scatter the light reflected from the cap surface so that there are no areas of disproportionately great intensity derived from reflection on that surface alone. The light from the reflector is therefore "softened".

The side and end surfaces are beam-forming in nature. Preferably, each forms at least a gross approximation to a parabola for the purpose of throwing a directed beam sideward relative to the perpendicular, while the cap surface serves more to illuminate the area more directly under the luminaire. To form true parabolic surfaces which are appropriate to the geometries involved not only involves considerable computation, but also a considerable expense in tooling. It has been found that optimum light distribution can be derived from surfaces having areas formed by circularly arcuate generators, there being more than one such generator for each surface, their radii being different. Such a construction creates a light distribution which is at least an approximation to that created by a true parabolic surface, and in some respects appears to be superior for the purposes of this invention.

Accordingly, and as can best be seen in FIG. **5,** surface **61** is formed by a first radius **70** and a second radius **71,** while surface **62** is formed by a first radius **72** and a second radius **73.** These surfaces are mirror images of one another, and the dimensions of one are the dimensions of the other. In both cases, the surface portions formed by the first radii are of larger radius and closer to the open end of the cavity, while the second radii are shorter than the first radii and lie farther within the cavity. The location of the centers of these radii are shown in the figure. A fairing or transition radius **74** is formed between the cap surface and the side surfaces. It has no necessary correlation to the parabolic approximation, although it may have, if desired. It is primarily intended to constitute a smooth transition between the side surfaces and the cap surface.

Surfaces **61** and **62** preferably are in the form of "bent planes", and accordingly, the cross-sections shown in FIG. **5** are generators which generate the respective surfaces by being moved parallel to, and at a constant distance from, the longitudinal axis. However, it will occasionally be found that, instead of using shapes which lie principally at constant distances from the longitudinal axis, some curvatures may be advantageously introduced into surfaces **61** and **62,** such as by bowing them outwardly. Such modifications remain within the concept of the invention.

End section **63** is preferably formed as a surface of revolution revolved around a central axis **80,** which axis lies in the plane of symmetry and normal to the longitudinal axis. Surface **63** has a radius C from this central axis, details of which will be found in the accompanying tables. The generator line **81** is shown in FIG. **3,** and in this surface, as well as in the other surfaces defined as generator surfaces, the term is used in a geometric sense of a line moved through space to generate a surface. The curvatures of surfaces **40** and **63** as shown are identical at the plane of symmetry, and the dimensions given for surface **40** are identical to those of surface **63,** and vice versa. Full details of only one are is shown in order to simplify the drawings. If, instead of having the light reflected identically by each of the side surfaces **61** and **62,** it is desired to have one throw its light farther than the other, then the curvatures of the two side surfaces may not be identical, but instead may be differently curved. Such a construction is still within the concept of the invention. In such case, a plane of symmetry will not exist between two mirror-image surfaces, but the plane would more properly be described as a central plane, i.e. the plane in which the axis of radiation lies, and the terms central plane and plane of symmetry are used interchangeably herein, as appropriate.

As will be seen in the drawings, the generator line **81**, and therefore the resulting surface **63** in vertical section, is an approximation to a parabola and is formed by a first radius **82** and a second radius **83**, which radii are preferably, but not necessarily, identical to radii **70–73**, respectively, and located at substantially the same elevations relative to the open end of the cavity. Therefore, the end surface constitutes a substantial continuation of side surfaces **61** and **62**. Central region **85** of end surface **40** is not necessarily a curve. Instead, it may constitute a bent plane with the curvature shown in FIG. **3**, and it is connected to the side surfaces by transition regions **86, 87** which are formed by radii and curves as shown in the drawings. Regions **85, 86** and **87** are not substantially important to the reflector's performance for the reason that, with respect to the heavy dashed line identified as "edge **88** of light-absorbing region", those portions toward the socket end, to the left of that edge line **88**, are painted flat black as is the socket shroud. Accordingly, substantially no reflection occurs from that end. Instead, substantially all reflection occurs from the side, end and cap surfaces.

One reason that these regions **85–87** are relatively unimportant is that little lamp flux impinges upon them due to the nature of the distribution of the flux from the lamp itself. A reason for painting these areas black is that otherwise they would reflect light toward the house side, frustrating one objective of the luminaire, which is to cast its light away from a pole or house, and not toward it, from a horizontal aperture.

The detailed construction of the presently preferred embodiment of reflector is shown in the following table. All dimensions are in inches, and the identification of dimensions relate to those which are shown in the accompanying drawings.

RADIUS DIMENSIONS

WL No.	RAD. A	RAD. B	RAD. C	RAD. D
WL-0	5.62	16.34	6.00	2.00
WL-1	5.62	16.34	6.00	2.00
WL-2	5.59	16.28	5.96	1.96
WL-3	5.50	16.18	5.87	1.78
WL-4	5.34	16.03	5.71	1.71
WL-5	5.03	15.71	5.40	1.40
WL-6	4.56	15.25	4.93	0.93
WL-7	3.91	14.59	4.28	0.81
WL-8	2.97	13.65	3.34	0.62
WL-8.5	2.31	13.00	2.65	0.50

OTHER DIMENSIONS

WL No.	RAD. A	RAD. B	RAD. C	RAD. D
AA 1.656	HH 2.375	QQ 7.68	XX 1.50	AF 0.62
BB 12.00	JJ 0.343	RR 7.87	YY 1.218	AG 9.375
CC 6.00	KK 4.68	SS 7.96	ZZ 2.375	AH 1.906
DD 6.312	LL 5.34	TT 7.515	AB 1.06	AJ1.50
EE 8.00	MM 6.28	UU 12.312	AC 0.375	AK 2.00
FF 4.312	NN 6.93	VV 7.515	AD 2.50	AL 1.25
GG 1.218	PP 7.40	WW 12.312	AE 2.00	

The reflector disclosed above is designed to use all of the following lamps:

175 Watt Mercury Vapor
250 Watt Mercury Vapor
250 Watt High Pressure Sodium
400 Watt Mercury Vapor
400 Watt Metallic Halide
400 Watt High Pressure Sodium

The location of the socket is moved as previously discussed, to place the lamp's center at the location required for a respective distribution of light.

Some considerations and features of this luminaire are shown in FIGS. **6–12.** For convenience, there has been set up a reference to a house side and a street side. Of course, there need not be a house or a street. Instead, the luminaire might be used to illuminate a parking lot or other open area far from a building. What is shown is a situation where the light distribution on one side of the luminaire itself extends to a lesser horizontal distance than on the other, and in which the shape of the illuminated region is quite carefully controlled, with sharp cutoffs at the edges, there being a substantially consistent and relatively constant illumination throughout the illuminated area, and a relatively sharp rate of decrease of brightness as one moves away from the area intended to be illuminated. This is accomplished, while using a horizontal aperture, and no refractors, thereby greadly reducing stray glare.

As to the illumination caused by this luminaire, initial attention is called to FIGS. **6** and **7.** In these figures there are shown two types of distributions which are defined as ANSI Type II and Type III, respectively. The Type II illumination casts a lesser throw onto the street side than the Type III illumination. In both cases, the illumination on the house side is about the same. Other patterns can be made by shifting the lamp along its axis, or by varying the shape and/or size of the reflector. The luminaire **90** is shown in both figures, and the illuminated area is shown in shaded line with boundaries **91, 92** respectively. These boundaries indicate the outer limit of substantial illumination from the luminaire as cast upon the ground. A pole **93** is schematically shown holding the luminaire above the ground.

The two different patterns were obtained by the use of the same reflector and lamp. The pattern of FIG. **6** was changed to that of FIG. **7** by shifting the lamp horizontally toward socket end **40.** This was done by moving the lamp socket toward the socket end, and shifting the socket upwardly in slot **54*a*.** The sideward throw was not appreciably changed. To change the sideward throw, one would move the lamp center of the vertically. Various combinations of movement are made to form other illumination patterns.

FIG. **8** shows the candlepower distribution of the lamps disclosed above. The heavy lines **66** indicate the candlepower intensity at the respective angles. It will be observed that a disproportionately small part of the radiation is radiated outside of the annulus.

FIG. **9** shows the interaction between the lamp and the reflector. The candlepower curve **66** of the lamp by itself is shown in dashed line, while the resulting candlepower curve of the lamp plus reflector is shown by line **95.** It will be seen that the reflector has modified the flux distribution of the lamp so that a minimum of light is projected toward the house side, while the major portion of light is efficiently projected on the street side where it is needed. This is one of the important consequences of the combination of the particular lamp and reflector, and still can be secured with a horizontal aperture.

FIGS. **10** and **11** show the effect of shifting the lamp along its axis of radiation. In FIG. **10,** the Type III distribution of FIG. **7** is shown. In this condition, the lamp is in the solid line position of FIG. **1, 1.*e*.** closer to the pole end itself. In this case, it will be found that the major proportion of the flux departs in a band **97**, as shown in FIG. **10**, and that this band will intersect the ground in the manner shown in FIG. **7**.

In FIG. **11**, the center of the lamp **35** is in the dotted line position shown in FIG. **1**, and in this case, the major proportion of the flux departs in band **98**, whose intersection with the ground is that shown in FIG. **6**.

FIG. **12** shows a section similar to that of FIG. **5**, the section being taken in a plane normal to that of the longitudinal axis. This figure illustrates the cut-off effect of the bottom edge **38** of reflector **37**. As will be seen, the lower edge acts as a cut-off for direct light from the lamp, and reflected light from the various surfaces will be substantially confined within the region defined by edges such as the major cut-off edge **99**. The scattering action of the facets is shown by ray **100**, whose reflected direction is indeterminate, but which is limited by the cut-off edge **99**.

The reflector shown is not a true parabola, but it is an approximation to one. A true parabola could be used. It would reflect a collimated beam of light toward the pavement. The directed beam produced by the illustrated reflector is not truly collimated, but is a projected beam, even though it is not a bundle of parallel rays, and tends to spread the light somewhat, as contrasted with a bundle of strictly parallel rays. In this luminaire, the beam directing effect is used to project a beam away from the surface. Beams are sent to both sides and away from the house. The blackened surface prevents light from being reflected to the house side. Light reflected from the surfaces and direct radiation from the lamp illuminate the area directly beneath the aperture and to either side and to the street side within the range ermitted by the cut-off edges. Together these beams and the direct radiation will form a reasonably uniform light pattern.

Some variation from the true collimation which would be produced by a parabola with the lamp at its focus has been found useful, because it does appear to give a more even distribution of light. The effect of this arrangement is shown in FIG. **12**, where two beams **110, 111** are shown emanating from the two circular portions **112, 113** of side surface **61**, that are formed by radii **71** and **70**, respectively. Of course, these beams will not be strictly collimated, because the cylindrical surfaces will tend to spread the beam, but the center of the lamp is spaced from the respective section between the center and the surface, so that at least some beam directing of the radiation from the lamp is accomplished. The term "beam-forming" or beam-directing is used to describe the function of the reflecting surfaces in forming a beam of light. The term "specular" is intended to define the function of reflection of light, in contrast to the dull and diffuse illumination produced by a matte surface.

To change the light distribution pattern, the lamp is shifted so as to radiate more or less light on the different portions of the reflector, and at different positions relative to the "quasi-focus" of the reflector, i.e., the location of the focus of the parabola which the sections approximate. It should be borne in mind that these light sources are not true points or lines, but physical structures of substantial length and width. Therefore, the definition of location of the axis of radiation relative to the quasi-focus must be somewhat approximate. It may be said in general that a downward displacement of the lamp will tend to increase the lateral throw. A displacement toward the end surface has a lesser effect than downward displacement, but does cause a farther throw onto the street side (see FIGS. **10** and **11**). In most practical applications, the axis of radiation will pass relatively near to the quasi-focus of the approximated parabola, and in the preferred form, will intersect this focus somewhere along the length of the axis of radiation. The approximated parabola can best be drawn by laying a french curve as close as possible to the cylindrical sections.

The dimensional notations WL in the drawings relate to the term "water line" frequently used in die-making operations, and the dashed lines following them is the number of inches up from the bottom edge **38**. All dimensions are referred to this water line. Thus, **WL–1** means a horizontal section taken 1 inch above the lower edge of the reflector.

The reflector shown is simple in shape, readily developed by a tool and die man, and easily produced in common and practical manufacturing operations. It is surprisingly effective in its control of high angle glare light and of distribution patterns on the ground. The distribution pattern may readily be varied by shifting the location of the lamp along its axis, and by manufacturing the reflector in variants of the example. The intensity of light may be varied by substituting lamps of different wattage. The construction is adapted to use with any suitable lamp of the class described, and may readily be scaled up or down as to size. The entire system may be placed in a rectangular enclosure of elegant simplicity.

Attention is further called to the fact that the socket end of the lamp is nearest the area being illuminated, and does not lie in the path of useful light.

This invention is not to be limited by the embodiment shown in the drawings and described in the description, which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

I claim:

1. In combination: a lamp which emits visible light, said lamp having an axis of radiation and the property of emitting a disproportionately large percentage of its luminous flux in an annulus bounded by a pair of surfaces of revolution generated around the axis by generator lines which, in an axial plane, diverge from the normal to the axis of radiation by no more than about 50°; and a reflector having a longitudinal axis, an imaginary central plane which includes said longitudinal axis and axis of radiation, and an open, inwardly concave cavity in which the lamp is placed, said cavity opening at a base plane parallel to the longitudinal axis, said cavity being bounded, at least in part, by the following reflecting surfaces:

a. a cap surface which overlays the cavity, and extends generally along and transverse to said longitudinal axis;

b. a pair of concave side surfaces, one on each side of the central plane, intersecting the cap surface, and extending generally along said longitudinal axis; and

c. a concave end surface intersecting and interconnecting both side surfaces and the cap surface, said surfaces being specularly reflective over the major portion of their areas, and having a beam-forming property with respect to light emitted by the lamp, the axis of radiation forming an acute angle with the longitudinal axis, and the flux within said annulus impinging upon each of said surfaces.

2. A combination according to claim 1 in which the cap surface is substantially planar.

3. A combination according to claim 2 in which some portions of the cap surface are modified by light-scattering facets.

4. A combination according to claim 1 in which the section-lines of the side which are formed by intersection with said surfaces by a plane normal both to the longitudinal axis and to said side surfaces, and in which the section-line formed by intersection of the end surface and a plane which includes a line in said central plane that is normal to the longitudinal axis, are at least approximations to parabolas.

5. A combination according to claim 4 in which said section lines comprise the arcs of at least two circles of different radius.

6. A combination according to claim 1 in which said side surfaces are generated by a concave arcuate generator line lying in a plane normal to the longitudinal axis and moved in a substantially straight line parallel to said longitudinal axis, said generator line being at least an approximation to a parabola.

7. A combination according to claim 6 in which said generator line comprises the arcs of at least two circles of different radius.

8. A combination according to claim 1 in which the end surface is generated by a concave arcuate generator line which lies in a plane inclusive of a central axis in said central plane which is normal to the longitudinal axis, and which generator line is moved through a circular arc around said central axis, the generator line being at least an approximation to a parabola.

9. A combination according to claim 8 in which said generator line comprises the arcs of at least two circles of different radius.

10. A combination according to claim 6 in which the end surface is generated by a concave arcuate generator line which lies in a plane inclusive of a central axis in said plane of symmetry which is normal to the longitudinal axis, and which generator line is moved through a circular arc around said central axis, the generator line being at least an approximation to a parabola.

11. A combination according to claim 10 in which each of said generator lines comprises the arcs of at least two circles of different radius.

12. A combination according to claim 11 in which the cap surface is substantially planar.

13. A combination according to claim 12 in which some portions of the cap surface are modified by light- and energy-scattering facets.

14. A combination according to claim 1 which further includes socket means for holding said lamp, said socket means being adapted to hold the lamp at different axial locations along said lamp axis.

15. A combination according to claim 11 which further includes socket means for holding said lamp, said socket means being adapted to hold the lamp at a plurality of different axial locations along said lamp axis.

16. A combination according to claim 1 in which the end of the cavity opposite the said end surface is substantially nonreflective.

17. A combination according to claim 8 in which the end of the cavity opposite the said end surface is substantially reflective.

18. A combination according to claim 1 in which the boundaries of the surfaces at the open edge of the cavity are coplanar.

19. A combination according to claim 11 in which the boundaries of the surfaces at the open edge of the cavity are coplanar.

20. A combination according to claim 1 in which a support holds the reflector above the ground, and the greater area of illumination extends away from the projection of the support on the ground, there further being provided a socket to receive and support the lamp, there being a socket at the end of the reflector away from the support, and the reflecting end section being the closer to the support.

21. A combination according to claim 1 in which the socket end of the lamp is deeper in the cavity of the reflector than the free end of the lamp, and in which the socket end of the lamp is the end farther removed from the said end surface.

22. A reflector for forming a field of radiated light from a lamp of the type which emits visible light, said lamp having an axis of radiation and the property of emitting a disproportionately large percentage of its luminus flux in an annulus bounded by a pair of surfaces of revolution generated around the axis by generator lines which, in an axial plane, diverge from the normal to the lamp axis by no more than about 50°, said reflector having a longitudinal axis, a central plane which includes said longitudinal axis and lamp axis, and an open, inwardly concave cavity in which the lamp is placed, said cavity opening at a base plane parallel to the longitudinal axis, said cavity being bounded, at least in part, by the following reflecting surfaces:

a. a cap surface which overlays the cavity, and extends generally along and transverse to said longitudinal axis;
b. a pair of concave side surfaces, one on each side of the central plane, intersecting the cap surface, and extending generally along said longitudinal axis;
c. a concave end surface intersecting and interconnecting both side surfaces and the cap surface, said surfaces being specularly reflective over the major portion of their areas; and means for supporting said lamp in the cavity, the said surfaces having a beam-forming property with respect to light emitted by the lamp, the means being so disposed and arranged as to support the lamp so that its axis of radiation forms an acute angle with the longitudinal axis, and the flux within said annulus impinges upon each of said surfaces.

23. A reflector according to claim 22 in which the cap surface is substantially planar.

24. A reflector according to claim 23 in which some portions of the cap surface are modified by light-scattering facets.

25. A reflector according to claim 22 in which the section-lines of the side and end surfaces which are formed by intersection with said surfaces by a plane normal both to the longitudinal axis and to said side surfaces, and in which the section-line formed by intersection of the end surfaces and a plane which includes a line in said central plane which is normal to the longitudinal axis are at least approximations to parabolas.

26. A reflector according to claim 25 in which said section lines comprise the arcs of at least two circles of different radius.

27. A combination according to claim 22 in which said side surfaces are generated by a concave arcuate generator line lying in a plane normal to the longitudinal axis and moved in a substantially straight line parallel to said longitudinal axis, said generator line being at least an approximation to a parabola.

28. A combination according to claim 1 in which the central plane is a plane of symmetry.

29. A combination according to claim 4 in which the central plane is a plane of symmetry.

30. A combination according to claim 21 in which the central plane is a plane of symmetry.

31. A reflector according to claim 22 in which the central plane is a plane of symmetry.

32. A reflector according to claim 25 in which the central plane is a plane of symmetry.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,786,248 Dated January 15, 1974

Inventor(s) WAYNE W. COMPTON

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 10	change "plane of symmetry" to --imaginary central plane (which may be a "plane of symmetry")--
Col. 2, line 18	change "plane of symmetry" to --central plane.
Col. 2, line 42	change "plane of symmetry" to --imaginary central plane--
Col. 3, line 37	"imaginary generated by a pair" should read --generated by a pair of imaginary--
Col. 4, line 33	"plane of symmetry" should read --central plane--
Col. 4, line 34	after "54" insert --which in this example is also a plane of symmetry--
Col. 4, line 57	before "plane" insert --central plane, which in this example is also a--
Col. 4, line 57	insert a comma after "symmetry"
Col. 6, line 65	'plane of symmetry' should read --"plane of symmetry"--
Col. 7, line 1	'central plane' should read --"central plane"
Col. 7, line 2	'plane of symmetry' should read --"plane of symmetry"--
Col. 7, line 3	after "appropriate." insert --The plane is imaginary--
Col. 7, line 14	'bent plane' should read --"bent plane"--
Col. 9, line 34	"ermitted" should read --permitted--
Col. 9, line 50	'beam-directing' should read --"beam-directing"--
Col. 10, line 11	'WL' should read --"WL"--

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,786,248 Dated January 15, 1974

Inventor(s) WAYNE W. COMPTON

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 11, line 9 (Claim 4, line 2) after "side" insert --surfaces--

Col. 11, line 12 (Claim 4, line 4) cancel "in which"

Col. 11, line 12 (Claim 4, line 5) "section-line" should read --section-lines--

Col. 11, line 42 (Claim 10, line 4) change "plane of symmetry" to --central plane--.

Col. 12, line 58 (Claim 25, line 2) cancel "and end"

Col. 12, line 61 (Claim 25, line 5) cancel "in which"

Col. 12, line 61 (Claim 25, line 5) "section-line" should read --section-lines--.

Signed and Sealed this

Fifteenth Day of February 1977

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,786,248 Dated January 15, 1974

Inventor(s) Wayne W. Compton

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 52, "is" should read --- can be ---.

Signed and Sealed this

Twenty-ninth Day of March 1977

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks